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The Bar Pattern Speed in NGC 7079

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Abstract. We have used 2D Fabry-Perot absorption-line spectroscopy of the SB0 galaxy NGC 7079 to measure its bar pattern speed, $\Omega_{\rm p}$. As in all previous cases of bar pattern speed measurements, we find a fast bar. We estimate that NGC 7079 has been undisturbed for *at least* the past Gyr or roughly 8 bar rotations, long enough for the bar to have slowed down significantly through dynamical friction if the disk is sub-maximal.

1. Introduction

The fundamental parameter in barred galaxy (SB) dynamics is their bar pattern speed, $\Omega_{\rm p}$, which can be parametrized by the ratio $\mathcal{R} \equiv D_L/a_B$, where D_L is the corotation radius and a_B is the bar semi-major axis. A bar is termed fast when $1.0 \leq \mathcal{R} \leq 1.4$. N-body simulations by Debattista & Sellwood (1998), following the theoretical work of Weinberg (1985), showed that dynamical friction on a bar from an isotropic dark matter halo preserves a fast bar only if the disk is very close to maximal, in the sense that the luminous disk provides most of the rotational support in the inner galaxy. Tremaine & Ostriker (1999) suggested that a flattened, rapidly rotating inner halo can reduce dynamical friction sufficiently to preserve fast bars even in sub-maximal disks, but Debattista & Sellwood (2000) showed that the halo rotation required is large; the stellar halo of the Milky Way shows no evidence for such large rotation.

Indirect evidence for fast bars in SB galaxies comes from hydrodynamical models of gas flow, particularly at the shocks. Three such studies are: $\mathcal{R} = 1.3$ in NGC 1365 (Lindblad *et al.* 1996), $\mathcal{R} = 1.3$ in NGC 1300 (Lindblad & Kristen 1996), and $\mathcal{R} = 1.2$ for NGC 4123 (Weiner *et al.* 2000, who also showed that a $80\% - 100\%$ maximal disk is highly favored in NGC 4123). A direct, model-independent method for measuring $\Omega_{\rm p}$, developed by Tremaine & Weinberg (1984) gives $\Omega_{\rm p} = \frac{1}{\sin i} \frac{<V_{los} - V_{sys}>}{<X>}$, where (X, Y) are galaxy-centered coordinates parallel and perpendicular to the disk's major axis, and all averages are at fixed Y and weighted by the luminosity. Using the Tremaine-Weinberg (TW) method with slit spectra, Merrifield & Kuijken (1995) and Gerssen *et al.* (1998) found fast bars in NGC 936 ($\mathcal{R} = 1.4 \pm 0.3$) and NGC 4596 ($\mathcal{R} = 1.15^{+0.38}_{-0.23}$) respectively.

No slow bars ($\mathcal{R} > 1.4$) in high surface brightness (HSB) galaxies have been discovered to date.

2. Observations and Results

We used the TW method to measure $\Omega_{\rm p}$ in NGC 7079, using a full-2D velocity field. We observed NGC 7079 with the Rutgers Fabry-Perot imaging interferometer on the CTIO 4m telescope. We used the CaII 8542.14 Å absorption line, redshifted to 8618 Å, scanning the spectrum from 8608 Å to 8631 Å, in steps of 1 Å, for a total of 25 exposures of 900 seconds each. Voigt profiles were fitted to the spectrum at each pixel of the reduced images, giving maps of the velocity and dispersion. Data extracted along the slit PAs of Bettoni & Galletta (1997, BG97) match their data with a worst reduced $\chi^2 = 1.2$ for 15 degrees of freedom. The rotation curve, which we then corrected for asymmetric drift, was extracted using a tilted ring fit.

We used ellipse fits to U, B, V, R and I exposures obtained at the CTIO 0.9m telescope to obtain $i = 49.87^{\circ}{}^{+0.23}_{-0.25}$, PA $= 78.8^{\circ} \pm 0.1^{\circ}$ and $a_B = 24.9''$. The $B-I$ map shows near-constant color for the disk and bulge separately, indicating uniform (or zero) internal extinction.

Applying the TW equation, we obtain $\Omega_{\rm p} \simeq 9.33 \pm 0.25$ km/s/$''$, which gives $D_L = 23'' \pm 3''$, so that $\mathcal{R} \simeq 0.9 \pm 0.1$, making this a fast bar. NGC 7079 is a currently undisturbed, HSB galaxy, offset only 0.3 mag from the Tully-Fisher relation of Courteau & Rix (1992). The nearest galaxy, ESO 287-37, is at a projected separation of 363 kpc; assuming a relative velocity of 300 km s^{-1}, their last closest approach would have been over 1 Gyr, or about 8 bar rotations, ago, long enough for a bar in a sub-maximal disk to have slowed down significantly. BG97 reported faint O[III] emitting gas out to $\sim 15''$ counter-rotating relative to the stars. If it originated in an accretion event, this gas, being retrograde, could not have added angular momentum to the bar. NGC 7079 must therefore be a maximum disk.

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